WATER CHLORINATION CONTROL IN VIRGINIA[1]

By Linn H. Enslow[2]

The following description of the method of chlorine control at water works, as practiced in Virginia plants, is intended to show how successfully chlorine may be applied at all times to waters, in the proper quantity to remove dangerous bacteria and yet give no objectionable tastes, odors or noticeable increase in corrosiveness. For practical service a description of the apparatus required and the directions necessary for its use are included.

The proper and efficient control of chlorination of water supplies is exceedingly simple. No test for the chlorine "*absorption factor*"[3] need be made unless this is desired as a matter of interest or for study of the characteristics of a particular water. It is no longer necessary to know the rate-of-flow of the water being treated or the rate-of-discharge of chlorine gas. Where the method of control is employed efficiently, it is no longer a necessity to know the strength of hypochlorite of lime. The only essential to the success of the control is that the individual makng it be not color blind and that he exhibit a willingness to make the test as often during the day as necessary. Chlorine control by the test herein discussed is practiced in twenty-eight plants in Virginia. In sixteen of these neither the superintendent nor the operators have had any training whatever in chemistry. The simplicity of the test appeals to all who have seen it made.

EQUIPMENT AND DIRECTIONS FOR USE

Having carefully considered all tests at present applicable to the estimation of free chlorine present in small quantities in water it was decided to make use of the well known ortho-tolidine test given in the Standard Methods of the American Public Health Association.

[1] Presented before the Philadelphia Convention, May 18, 1922.

[2] Division of Engineering, State Department of Health, Richmond, Va.

[3] Chlorine Absorption and the Chlorination of Water, Wolman and Enslow, Jour. Ind. and Eng. Chem., March, 1919.

Water Chlorination Control by the Absorption Method, Wolman, Eng. News-Record, April 14, 1921.

The Laboratory of this Division keeps on hand standard color solutions prepared from potassium bichromate and copper sulphate and also ortho-tolidine solution. There are only two stock color solutions. No. 1 is prepared to represent the color produced by 0.1 p.p.m. and No. 2 that produced by 0.2 p.p.m. free chlorine, when ortho-tolidine solution is added to a water sample containing these

FIG 1

quantities of chlorine. As often as necessary, small bottles (about 50 cc. capacity) are filled with the standard color solutions and an eight ounce bottle, equipped with a stopper holding an eye-dropper, is filled with the ortho-tolidine solution. These, together with a third empty bottle of the same size and tint of glass as the two holding the color standards, constitute the "outfit," which is packed in a mailing carton for shipment to any plant where needed. The

third bottle is intended for the water sample collected for the test, to indicate whether the chlorine dose is correct. Below is a copy of the directions supplied with the testing outfit. The second set of instructions is intended for framing or otherwise posting near the chlorination equipment, for convenience of new operators or others not entirely familiar with the test. The complete "outfit" is shown in figure 1, with instructions in the background. Wherever possible, we prefer to have someone thoroughly familiar with the test show the operators the exact details. The mere fact that it is a chemical test will frighten some and it is highly desirable, therefore, in order to avoid the likelihood of the test not being used, to demonstrate its simplicity first and to give the detailed instructions later.

Test for free chlorine in chlorinated waters

Apparatus: 1 empty bottle for collecting sample for comparison with standards; 1 bottle of ortho-tolidine solution. 1 dropping stopper or eye dropper (to be used with bottle); 2 standard color solutions representing 0.1 parts and 0.2 part per million of chlorine; 1 blue-glass nitrogen electric lamp for night testing.

Sampling point: A tap on the system not more than 25 nor less than 5 feet beyond the point at which the chlorine enters the water. (Note: Size of tap is of no importance, but a long threaded nipple extending into the pipe to a point near its center will produce a more reliable sample than otherwise obtainable.)

Procedure

1. Open valve on tap and allow water to waste for a few seconds. Collect a pint or more of sample slowly in a *clean* glass jar or bottle. Whirl the water in the glass container to obtain a thorough mixing for a second or two.

2. With the aid of the dropping stopper or dropper add 5 drops of the ortho-tolidine solution to the empty sample bottle (No. 3).

3. Fill the bottle with the water sample collected in the jar, but do not overflow it.

4. Allow the bottle containing the chemical and water mixture to stand about five minutes in warm weather or ten minutes in cold weather. (Note: The time required to allow the mixture to stand is for a two-fold purpose. The first is in order that the reaction of the free chlorine on matter contained in the water treated may take place. The second is to allow time for the free chlorine remaining after the chemical reaction to combine with the chemical added to produce the color reaction.)

5. After standing the required time, compare the color produced in the sample (No. 3) with the two standards No. 1 and No. 2. The color should be darker than No. 1 but *not* darker than No. 2. If lighter than No. 1 the chlorine dose is too low and should be increased. If darker than No. 2 the dose should be decreased. (*Note:* At night it is necessary to compare colors under a pure white or a blue-white light.)

6. In case a test shows that a change of dose in either direction is necessary, first change the dose and then wait about 10 minutes after the change before making a new test to see if the dose is correct. This time is required to allow the new chlorine dose to become constant at the sample tap.

The importance of test

7. The test should be made *at least* every eight hours during constant rate of pumping or as often as the rate of pumping is changed.

The *most important* times at which to make the test at plants treating water that has *not* been filtered are three.

a. After rains or other disturbances that cause the water to become muddy or even slightly turbid. At such times the chlorine dose should be raised to almost double before making test. Should the test then indicate too heavy a dose, cut it down to a proper one. (Note: The presence of a small quantity of mud in the water will cause the color to appear darker than it really is. At such a time color in excess of No. 2 should be obtained as indication of an effective dose.)

b. If the water becomes considerably muddy the test is valueless. In such cases apply chlorine until the sample drawn has a distinct odor of chlorine after standing the required length of time and then shaken.

c. When the water shows signs of clearing up after the stream has "run down," the chlorine dose can be reduced by degrees and tests made to show whether the dose is correct.

8. The Engineering Division of the State Board of Health at Richmond, Virginia, should be notified at least two weeks before the bottle of chemical solution has been all consumed. The solution and new color standards will be supplied as often as necessary and without charge.

Chlorine dose control

(Outline to be posted at the sterilization station for convenience of operators.)

1. Open sample cock. Allow to run few seconds. Catch one pint or more in clean glass jar or bottle and whirl the water a second to mix.

2. Place 5 drops chemical solution from dropper bottle into sample bottle (No. 3). Fill bottle with water from sample jar.

3. Allow to stand 5 minutes in warm or 10 minutes in cold weather.

4. Compare sample with standard color solutions No. 1 and No. 2 by looking through them placed side by side above a white surface. A difference in color is more noticeable if looking through them at an angle from above.

Correct dose: Color is darker than No. 1 but *not* darker than No. 2.

Dose too low: Color is lighter than No. 1.

Dose too high: Color is darker than No. 2.

(*Note:* For night testing a pure white or a blue-white light, such as obtained from a blue-glass nitrogen filled Mazda lamp, is necessary.)

5. Change dose if necessary. Wait 10 minutes. Make a new test. If correct dose is not obtained keep changing the dose until it is correct.

6. *Raise dose immediately water gets muddy* and make test *after* raising.

Lower dose when water clears up. Make test *after* lowering.

Change dose immediately each time after changing pump rate and make test.

Make test each 8 hours whether necessary or not.

(*Note:* In case of muddy water to be chlorinated color test cannot be used. Increase chlorine until sample after standing 10 minutes smells of chlorine when shaken up.)

Caution: Keep standards out of direct sun-light when not in use, preferably in dark place. Order more test solution before supply gets low.

Engineering Division,
State Department of Health,
Richmond, Va.

We are convinced that the expense of supplying such outfits as often as necessary has been a thoroughly good investment of funds. The return is adequate to warrant its continuance.

A FEW FACTS CONCERNING CHLORINE CONTROL

As stated above, where high turbidity is encountered the test for residual chlorine is useless. Here the "nasal-control" must be used. Even then, as will later be shown, the effectiveness of chlorination falls down under certain conditions.

Certain spring waters of low organic content and high bi-carbonate of lime content will not stand a residual free chlorine content of slightly more than 0.1 p.p.m., without producing a slight odor of hypochlorous acid at the cold water taps and considerable odor at the hot water taps. Certain other waters have been treated to allow about 0.3 p.p.m. free chlorine to remain after 10 minutes and without any detectable odors or tastes resulting. The general average of waters in Virginia, however, will not safely stand more than 0.2 p.p.m. residual without danger of odors occurring at the service taps. We have selected, therefore, the most satisfactory range as that between 0.1 and 0.2 p.p.m. It might be added here that this same "outfit," with modified control, is being used for chlorination control of swimming pools and sewage disposal plants.

Prior to the institution of the test at water plants chlorine was considered like unto a dose of castor oil at many places. It was conceded at times as necessary. The citizens were concerned more with getting rid of chlorination and less in the matter of drinking a few bacteria. When the reports from the Health Department indicated dangerous pollution, up would go the chlorine dose and the taste with it. Perhaps in many instances the organic matter had gone down already in the water or the high water in the stream

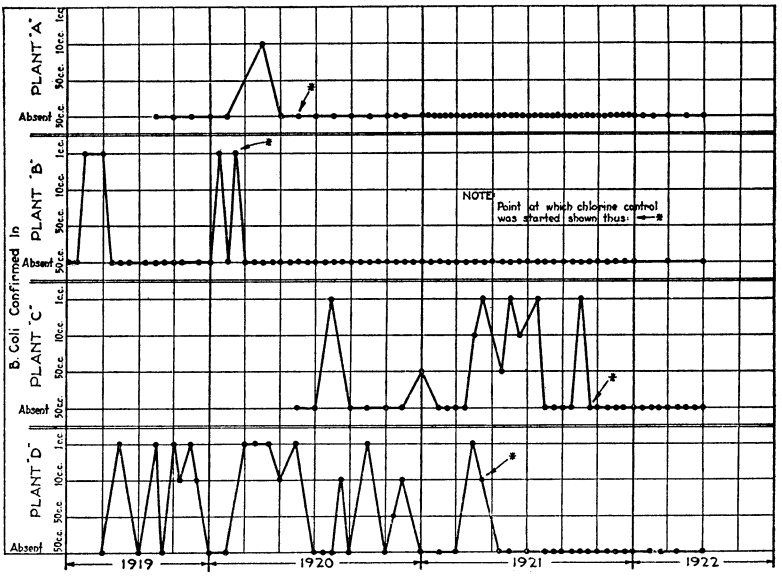
B. Coli Confirmed In
PLANT 'A'
PLANT 'B'
PLANT 'C'
PLANT 'D'
Absent
1c.c.
10c.c.
50c.c.
NOTE
Point at which chlorine control was started shown thus: —*
1919
1920
1921
1922

FIG. 2*a*

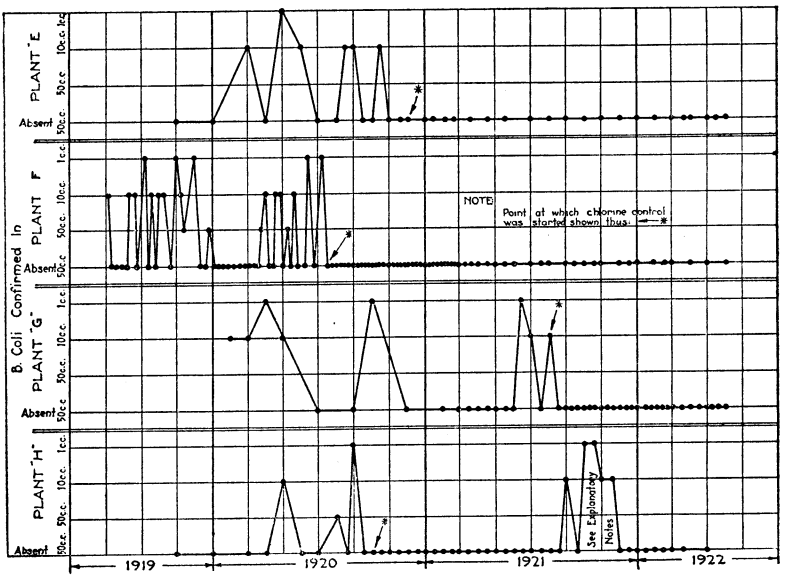
B. Coli Confirmed In
PLANT 'E'
PLANT 'F'
PLANT 'G'
PLANT 'H'
Absent
1c.c.
10c.c.
50c.c.
NOTE
Point at which chlorine control was started shown thus: —*
See Explanatory Notes
1919
1920
1921
1922

FIG. 2*b*

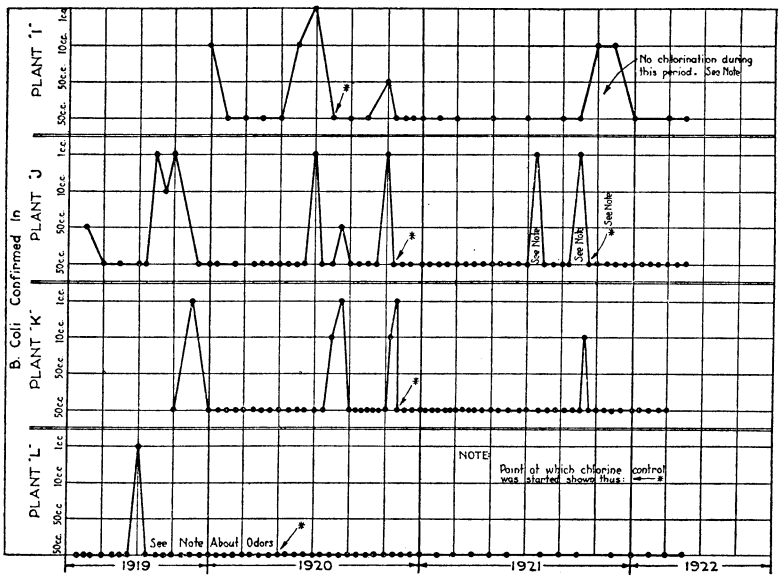
B. Coli Confirmed in
PLANT 'I'
PLANT 'J'
PLANT 'K'
PLANT 'L'
1cc.
10cc.
50cc.
No chlorination during this period. See Note
See Note
See Note
See Note
NOTE:
Point at which chlorine control was started shown thus: *
See Note About Odors
1919
1920
1921
1922

FIG. 2c

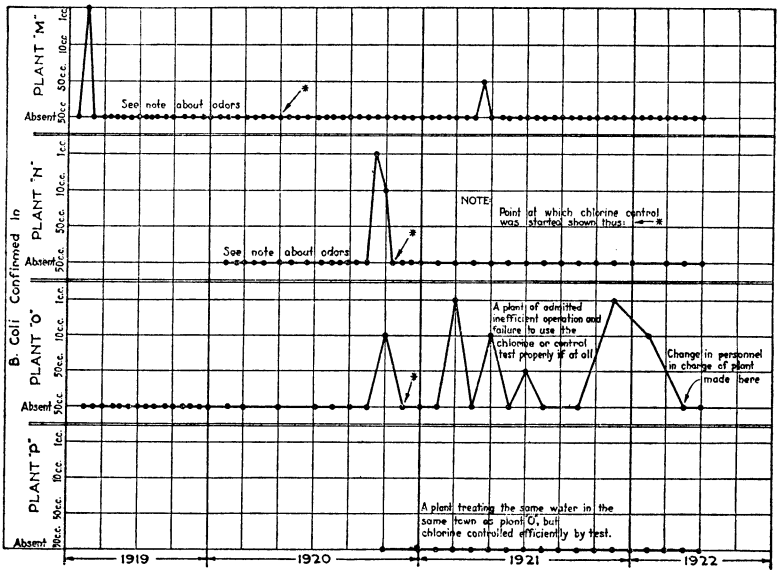
B. Coli Confirmed in
PLANT 'M'
PLANT 'N'
PLANT 'O'
PLANT 'P'
1cc.
10cc.
50cc.
Absent
See note about odors
See note about odors
NOTE:
Point at which chlorine control was started shown thus: *
A plant of admitted inefficient operation and failure to use the chlorine or control test properly if at all
Change in personnel in charge of plant made here
A plant treating the same water in the same town as plant 'O', but chlorine controlled efficiently by test.
1919
1920
1921
1922

FIG. 2d

had subsided before the laboratory report was received by the authorities. The chlorine dose was raised then at a time when unnecessary, with resulting complaints from the consumers about odors and from the superintendent of water works on corrosion of meters, etc. The complaints from consumers, and a possible word from the town "boss," resulted in a reduced chlorine dose, if not in its complete discontinuance for a while. The end result was the almost universal "ups and downs" of the curves showing the B. coli content of the water samples collected by local health officers or others. At certain times the sample showed practical sterility, to be followed immediately by the next sample containing B. coli present in 1 cc. or less. In almost every instance, except at efficiently operated filter plants, this was the case. It is gratifying to note, from the curves shown in figure 2, that with but one or two exceptions all of the twenty-eight plants, where chlorine in one form or another is being used, the B. coli content has remained constantly absent in 50 cc. quantities, since the adoption of control through use of the test here described.

The test, in addition to being used by operators, is used by city managers, superintendents and others on tap samples in their office, to check plant operation, provided the tap supplies water which received treatment not more than 8 hours prior to sampling.

The curves in figure 2 in certain instances call for explanatory remarks, as follows:

Arrow and asterisk indicate the date on which chlorine control was started through use of the outfit. In selecting plant records for presentation, those were taken which show the poorest results prior to or since the control-test was begun. Several filter plants are included, but none of them have trained operators, who had any knowledge of chemical tests prior to use of the control-test.

Plant C: Had no chlorination until the summer of 1921.

Plant D: Chlorine test outfit furnished in November 1920, but operator was holding dose too low because of fear of producing tastes. A demonstration was made in 1921, holding 0.2 p.p.m. free chlorine without tastes, which convinced him that this dose was satisfactory. Since this time results have been satisfactory.

Plant F: Characteristic of a plant where chlorine was insufficient in 1919. When raised too high odors and taste resulted, with a reduction to a point too low again. Since the test was begun no odor complaints have been registered and no B. coli have passed.

Plant G: Preferred to run excess chlorine with odors during latter part of 1920 and early 1921. Change of administration in spring of 1921 and chlorine

reduced to point too low. Since test began results have been satisfactory in all respects.

Plant H: An admirable example of where chlorine control was possible through test until early fall of 1921, when a new road was under construction along sides of stream fed by limestone springs and sink-holes. Heavy rains and resulting turbidity caused sudden appearance of b. coli in treated water. Representatives from this office visited plant. Chlorine raised to obtain more than 0.2 p.p.m. residual free chlorine with turbidity of about 150. Sample collected several hours later in town showed B. coli in 10 cc. Since this time the chlorine is increased to give a decided odor at taps in town during the run of muddy water. As a result of the sudden turbidity increases (sometimes to about 2000) and attendant factors of danger, the corporation owning this supply is now constructing a filter plant to care for the conditions under which chlorination alone is entirely unsatisfactory and unreliable.

Plant I: An example of what may happen where authorities fail to provide available extra chlorination equipment, which may be used in emergencies. In this case no attempt on the part of the operator had been made to provide even hypochlorite of lime and a barrel for emergencies. The control by test had proven very satisfactory. In the fall of 1921 the chlorinator began giving trouble. It finally went out of commission completely and no particular effort was made to obtain new equipment for several weeks. Conditions existing as stated were found by representative from this Department making a visit as a result of two samples showing B. coli present in 10 cc. Hypochlorite of lime treatment began immediately thereafter and continued until chlorinator could be sent away for repairs and returned to service.

Plant J: Another case of chlorinator troubles upon two occasions in the fall of 1921. Chlorinator in each case repaired on the ground as soon as possible, but there is no excuse for failure to provide emergency chlorination equipment and hypochlorite of lime or to have available duplicate liquid chlorine equipment. Almost universally the plants in Virginia now have emergency equipment, duplicate chlorinator, parts of same, or both. At this particular place, prior to advent of the control test, there were times when the consumers refused to drink the treated water because of the excessive chlorine dose. Springs of questionable quality were being used instead.

Plant K: Prior to adoption of control test at the plant the City Health Department had been making tests at the laboratory in town only, which was a result of a misunderstanding of the use of the test. Daily bacteriological examinations are made of tap samples. In the fall of 1920, the operator at the filter plant was provided with an outfit and tests were made there. After leaving the plant the water passes through a large open reservoir, which probably accounts for the single tap sample which shows B. coli present in 10 cc. quantities since control began.

Plant L: Treating a limestone spring water subject to sudden pollution after rains. Prior to use of test the chlorine dose during the majority of the time produced the hypochlorous acid odor at the taps. The residual at this plant is kept down to 0.1 p.p.m., or slightly more, with satisfactory results.

Plant M: Prior to adoption of control test complaints of odors were frequent.

Plant N: Same remarks as plant M.

Plant O: Plants O and P are treating the same water in the same town.

Plant P: Plant P, which produces efficient results, is owned by an industrial corporation. Plant O is owned by a municipality and until recently was poorly operated and managed, regardless of efforts on the part of this Division to obtain an improvement. Repeated warnings to the authorities, calling attention to the poor efficiency and careless operation of the plant, have had the desired effect. A change made in the personnel in charge of the plant was recently made. The "fall" in the B. coli curve to a point indicating effective chlorine control, if nothing more, is gratifying. The curves of plants O and P are purposely given to illustrate what may be accomplished with and without the proper chlorine control.

SUMMARY

An attempt has been made to describe a simplified method of chlorine dose-control adaptable to use by those without training in chemistry.

Diagrams have been given to show that an improved quality of water may be produced and that odors due to chlorine or hypochlorites *as such* may be eliminated through use of the control-test properly applied.

In treatment of water and sewage, it is no longer necessary to know the exact volume being treated nor the exact rate-of-feed of the chlorine in order that efficient treatment may result. The necessity of making tests to obtain the "chlorine absorption" factor for a given water no longer exists. A test outfit, non-fragile, compact, of simple make-up and manipulation, of practical value to waterworks personnel, health officers and others, has been assembled and supplied without charge at points of usefulness. Results obtained warrant the continuance of the practice of supplying such outfits or of replacing parts where necessary.